Comparison of MR and CT Myelography in Imaging the Cervical and Thoracic Spine

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Comparison of MR and CT Myelography in Imaging the Cervical and Thoracic Spine

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MR imaging and CT myelography were compared in a retrospective study of 38 patients with suspected lesions of the cervical and thoracic spinal canal and cord. Twenty-eight abnormal cases were found, including spondylosis (9), tumors (8), intramedullary cavities (3), arachnoiditis (3), disk-space-centered infection or osteomyelitis (2), nonneoplastic cord swelling (2), and CSF-borne metastasis (1).

MR was equal or superior to CT myelography in depicting cases of cord enlargement, cord compression, and cord atrophy, providing better tissue characterization, no shoulder artifact, and no limitation caused by CSF block. CT myelography was superior to MR in depicting cases of spondylosis and arachnoiditis. It showed superior spatial resolution, which was most pronounced when comparing axial images and hence particularly superior in detecting the lateral extent of disk herniation. Use of surface coils and thin imaging sections is essential for accurate and complete MR evaluation of the cervical and thoracic spine.

CT has been accepted as an effective imaging technique for evaluating the spine. Its use, however, is limited in the cervical and thoracic spine because of the lack of epidural fat in this region. CT myelography performed after intrathecal introduction of water-soluble contrast material improves the contrast sensitivity of CT, but it is invasive and has known side effects [1–7].

Numerous reports have described the potential of MR as a valuable method of imaging the spine, and have compared MR with CT and CT myelography [8–15]. To help determine the role of MR in the evaluation of the cervical and thoracic spine, a comparative study of MR and high-resolution CT myelography was performed.

Materials and Methods

We retrospectively reviewed 38 patients with suspected lesions of the cervical or thoracic spine who underwent both MR and CT myelography. No effort was made to conceal the diagnoses from the reviewers. The patients ranged in age from 1–75 years; 18 were males and 20 were females. In 10 cases no abnormality was found by either imaging technique. The 28 abnormal findings included nine cases of spondylosis, eight neoplasms, three cases of arachnoiditis, three intramedullary cavities, two cases of disk-space infection, two cases of nonneoplastic cord swelling, and one case of CSF-borne metastases. Seventeen cases involved the cervical and 11 involved the thoracic spine.

Surgical or pathologic proof was available in 16 abnormal cases, and clinical and radiographic evidence was available in the remaining 12.

MR was performed with a Siemens Magnetom 0.5-T (initially operating at 0.35 T) or 1.5-T unit. Spin echo (SE) sequences were used yielding three images of the same anatomic level: a T1-weighted image (TR 300 or 500 msec, TE 30 msec), a spin-density-weighted image (TR 1500 or 1800 msec, TE 30 msec), and a T2-weighted image (TR 1500 or 1800 msec, TE 120 msec). A body coil was used in seven cases, a head coil was used in nine cases, and a surface coil was used in 12 cases. Slice thickness was 5 mm for all surface-coil images except one case, in which a 10-mm thickness was used. Ten-millimeter sections were used...
for all head- and body-coil images except one case, in which the head coil and 5-mm sections were used. Sagittal images were obtained in all cases, axial images in 18, and coronal images in five. Images were processed on a 256 x 256 matrix corresponding to 1.2-mm² pixel size in all examinations.

CT images were obtained after myelography with water-soluble contrast material on a third-generation scanner*, using 2.0-mm axial scans. Delayed CT scanning 8–24 hr after initial examination was performed in four cases.

In the 38 cases, 43 final radiologic diagnoses were made and these were divided into six categories: normal (10), cord swelling (eight), cord atrophy (seven), cord compression (10), extradural lesions without cord compression (five), and arachnoiditis (three). Five of the 28 abnormal cases were included in two different radiologic categories, yielding 33 total abnormal final diagnoses. CT scans and MR images were compared to evaluate the ability of each imaging technique to detect the abnormality and to determine its cause. Reasons for failure or superiority of MR compared with CT myelography were noted.

Results

In the 10 normal cases, MR and CT myelography were equivalent in depicting the normal cord and surrounding CSF space. In the remaining 33 radiologic diagnoses, MR was superior to CT myelography in nine instances, equivalent in 13, and inferior in 11. Results are summarized in Tables 1–4. The remaining five radiologic diagnoses will be discussed separately.

Cord Enlargement

In all eight cases, cord enlargement (Table 1) was detected equally well by MR and CT myelography. However, MR was superior to CT myelography in determining the cause of the abnormality in three cases. In one case of hematomyelia (Fig. 1), CT myelography showed nonspecific cord enlargement while MR showed increased signal of the lesion on the T1- and T2-weighted images. The chemical-shift-imaging technique [16] was employed and showed this to be due to hemorrhage, not to fat. MR was superior in another case of an intramedullary cord cyst at the level of T2, in which MR showed the cavity, which was not seen with delayed CT myelography because of shoulder artifacts. The third case in which MR was superior was one of ependymoma of the cervical cord. CT myelography showed low-density enlargement of the cord. MR showed both the soft-tissue and fluid components of the lesion, confirming that it was a tumor and not a congenital hydromyelia. In no case of cord enlargement was CT myelography superior to MR.

Cord Atrophy

In seven cases of cord atrophy (Table 2) MR was equal to CT myelography in detecting the abnormally small cord in three cases and inferior to CT myelography in four cases. In one of these four cases, MR using surface coil and 5-mm sections showed the atrophic cord but failed to detect a 2-

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**TABLE 1: Cord Swelling**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age</th>
<th>Gender</th>
<th>Diagnosis</th>
<th>MR Coil</th>
<th>MR (Compared with CT Myelography)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>75</td>
<td>F</td>
<td>Ependymoma*</td>
<td>Surface</td>
<td>Superior</td>
</tr>
<tr>
<td>2</td>
<td>52</td>
<td>M</td>
<td>Thoracic cord cyst</td>
<td>Surface</td>
<td>Superior</td>
</tr>
<tr>
<td>3</td>
<td>41</td>
<td>M</td>
<td>Cord hemorrhage*</td>
<td>Head</td>
<td>Superior</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
<td>M</td>
<td>Radiation myelitis</td>
<td>Head</td>
<td>Equivalent</td>
</tr>
<tr>
<td>5</td>
<td>41</td>
<td>F</td>
<td>Intramedullary CSF metastasis</td>
<td>Head</td>
<td>Equivalent</td>
</tr>
<tr>
<td>6</td>
<td>35</td>
<td>F</td>
<td>Myelitis*</td>
<td>Head</td>
<td>Equivalent</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>F</td>
<td>Glioma*</td>
<td>Body</td>
<td>Equivalent</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>F</td>
<td>Intramedullary tumor</td>
<td>Body</td>
<td>Equivalent</td>
</tr>
</tbody>
</table>

*Histologically confirmed.

**TABLE 2: Cord Atrophy**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age</th>
<th>Gender</th>
<th>Etiology</th>
<th>MR Coil</th>
<th>MR (Compared with CT Myelography)</th>
</tr>
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<tbody>
<tr>
<td>9</td>
<td>26</td>
<td>M</td>
<td>Cord cavity</td>
<td>Surface</td>
<td>Inferior</td>
</tr>
<tr>
<td>10</td>
<td>40</td>
<td>F</td>
<td>Surgery</td>
<td>Surface</td>
<td>Equivalent</td>
</tr>
<tr>
<td>11</td>
<td>62</td>
<td>F</td>
<td>Surgery</td>
<td>Surface</td>
<td>Equivalent</td>
</tr>
<tr>
<td>12</td>
<td>42</td>
<td>M</td>
<td>Trauma</td>
<td>Head</td>
<td>Equivalent</td>
</tr>
<tr>
<td>13</td>
<td>34</td>
<td>F</td>
<td>Unknown</td>
<td>Body</td>
<td>Inferior</td>
</tr>
<tr>
<td>14</td>
<td>53</td>
<td>M</td>
<td>Cavity</td>
<td>Body</td>
<td>Inferior</td>
</tr>
<tr>
<td>15</td>
<td>36</td>
<td>F</td>
<td>Unknown</td>
<td>Body</td>
<td>Inferior</td>
</tr>
</tbody>
</table>

*Histologically confirmed.

**TABLE 3: Cord Compression**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age</th>
<th>Gender</th>
<th>Diagnosis</th>
<th>MR Coil</th>
<th>MR (Compared with CT Myelography)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>71</td>
<td>F</td>
<td>Meningioma</td>
<td>Surface</td>
<td>Superior</td>
</tr>
<tr>
<td>17</td>
<td>48</td>
<td>F</td>
<td>Herniated cervical disk*</td>
<td>Surface</td>
<td>Superior</td>
</tr>
<tr>
<td>18</td>
<td>33</td>
<td>M</td>
<td>Herniated cervical disk*</td>
<td>Surface</td>
<td>Superior</td>
</tr>
<tr>
<td>19</td>
<td>51</td>
<td>F</td>
<td>Herniated thoracic disk</td>
<td>Surface</td>
<td>Superior</td>
</tr>
<tr>
<td>20</td>
<td>39</td>
<td>M</td>
<td>Meningioma*</td>
<td>Surface</td>
<td>Superior</td>
</tr>
<tr>
<td>21</td>
<td>73</td>
<td>M</td>
<td>Extruded disk fragment</td>
<td>Head</td>
<td>Superior</td>
</tr>
<tr>
<td>22</td>
<td>66</td>
<td>M</td>
<td>Cervical subluxation*</td>
<td>Head</td>
<td>Inferior</td>
</tr>
<tr>
<td>23</td>
<td>41</td>
<td>F</td>
<td>Intramedullary metastasis</td>
<td>Head</td>
<td>Equivalent</td>
</tr>
<tr>
<td>24</td>
<td>44</td>
<td>M</td>
<td>Vertebral osteomyelitis*</td>
<td>Body</td>
<td>Equivalent</td>
</tr>
<tr>
<td>25</td>
<td>51</td>
<td>M</td>
<td>Schwannoma*</td>
<td>Body</td>
<td>Inferior</td>
</tr>
</tbody>
</table>

*Histologically confirmed.

**TABLE 4: Extradural Lesions Without Cord Compression**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age</th>
<th>Gender</th>
<th>Diagnosis</th>
<th>MR Coil</th>
<th>MR (Compared with CT Myelography)</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>66</td>
<td>F</td>
<td>Disk space infection*</td>
<td>Surface</td>
<td>Superior</td>
</tr>
<tr>
<td>27</td>
<td>39</td>
<td>M</td>
<td>Cervical disk herniation*</td>
<td>Surface</td>
<td>Inferior</td>
</tr>
<tr>
<td>28</td>
<td>47</td>
<td>M</td>
<td>Cervical bony bars*</td>
<td>Head</td>
<td>Inferior</td>
</tr>
<tr>
<td>29</td>
<td>52</td>
<td>F</td>
<td>Cervical disk bulge</td>
<td>Head</td>
<td>Equivalent</td>
</tr>
<tr>
<td>30</td>
<td>50</td>
<td>M</td>
<td>Cervical bony bars</td>
<td>Body</td>
<td>Equivalent</td>
</tr>
</tbody>
</table>

*Histologically confirmed.

* Siemens Somatom 2, DR3 or DRH.
mm associated cavity, which was 3 cm in length and was seen on delayed CT scans (Fig. 2). In the other three cases in which MR was inferior, slice thickness was 10 mm and body coil was used, resulting in low spatial resolution. These three cases included a case of atrophy with associated cord arteriovenous malformation, a posttraumatic cavity, and atrophy associated with arachnoiditis. In no case of cord atrophy was MR superior to CT myelography.

**Cord Compression**

In 10 cases of cord compression (Table 3) MR was superior to CT myelography in five cases, equivalent in two cases, and inferior in three cases. In two of the three cases in which MR was inferior (a cervical intradural schwannoma and a cervical disk herniation), slice thickness was 10 mm and surface coil was not used. In the third case, a herniated cervical disk, CT myelography showed the lateral extent of disk herniation better than MR did, and although surface-coil imaging and 5-mm sections were used, neither axial nor interdigitated images were obtained. Of the five cases in which MR was superior, two cases (a cervical disk herniation and a case of a presumed extruded disk fragment) showed serious degradation of the CT myelography images by shoulder artifacts. In a third case (of presumed thoracic disk herniation), MR allowed better differentiation of the compressed cord, narrowed CSF space, and thoracic disk than CT myelography did (Fig. 3). In the remaining two cases (meningiomas of the thoracic spine), CT myelography showed only the inferior margin of the lesion because of CSF block. No attempts were made to position water-soluble contrast material above the lesion. MR in these two cases showed the upper border and true size of the lesion and its interface with the cord (Fig. 4). In addition, both these lesions demonstrated a low signal intensity on the T2-weighted image, a feature previously reported in intracranial meningiomas [17].
Extradural Lesions Without Cord Compression

In five cases of extradural lesions without cord compression (Table 4), MR was superior to CT myelography in one case, equivalent in two cases, and inferior in two cases. MR was superior in a case of disk-space-centered infection by showing decreased signal in the disk space and adjacent vertebral bodies on the T1-weighted images secondary to infection (Fig. 5). Both MR and CT myelography showed the paravertebral mass and the mild extradural encroachment on the anterior aspect of the subarachnoid and epidural spaces. The changes in the vertebral body were not convincing on CT.
Fig. 5.—Disk-space-centered infection.
A, CT myelogram shows paravertebral mass and extradural soft-tissue density ventral to cord causing narrowing of subarachnoid space (arrow). Vertebral body shows mild focal loss of bone density ventrally.
B, Sagittal T1-weighted MR image demonstrates abnormally decreased signal from two adjacent vertebral bodies and some loss of signal from disk space. Extradural extension ventral to cord is also seen (arrow).

Fig. 6.—Cervical disk herniation.
A, Axial CT myelogram shows soft-tissue density anterior and lateral to cord with narrowing of subarachnoid space (arrow).
B, Sagittal T1-weighted MR image shows bulging of C5-C7 disk (arrow).
C, Axial T1-weighted MR image fails to show lateral extent of disk as well as CT did.

myelography. On MR, however, the vertebral body changes were clearly demonstrated and the nature of the process was defined as bone-centered. The clinical management was planned accordingly. In one case of osteophytes indenting the subarachnoid space and the intervertebral foramina in the cervical spine, MR was inferior to CT myelography. The case was imaged with a head coil and 10-mm sections. However, in another case in which a surface coil and 5-mm sections were employed, CT myelography was superior to MR because superior spatial resolution allowed CT to show the lateral extent of a cervical disk herniation better than MR did (Fig. 6).

Arachnoiditis

In three cases of arachnoiditis, MR was equivalent to CT myelography in one case and inferior in two cases. In one of the cases in which MR was inferior, MR did provide complementary information by showing no lesion at a site of CSF block on CT myelography. Although MR alone would have missed the diagnosis, lack of abnormal signal from the site of the CSF block indicated arachnoid adhesions and not a mass as the cause of the block on CT myelography. In this case and in one other case, MR did not show arachnoid adhesions or multiple loculated pockets of CSF that were evident on CT myelography.

Coil Selection

The importance of surface-coil imaging in evaluating the cervical and thoracic spine is demonstrated in Table 5. Regardless of the diagnostic category, a surface coil was used in 14 cases, of which MR was superior to CT myelography in seven, equivalent in three, and inferior in four. On the other
disk herniation was therefore not made before MR was per­
characterized by low signal from the disk space and adjacent
and posteriorly at the level of the lesion,
and disk. Because of the lack of difference in density between
disk herniation (Fig. 3) , MR differentiated cord, vertebral body,
ependymoma by a signal intensity pattern different from pa­
formed . MR also detected the
renchyma and
chemical-shift technique [16] can be used to distinguish the
complete
a surface coil and thin sections are used. Advantages of MR
include tissue characterization, lack of shoulder artifact, and
complete delineation of the lesion in spite of CSF block (Table
6). The contribution of tissue characterization was significant
in six of our 33 abnormal diagnoses. Cord hemorrhage (Fig.
1) was characterized by a relative signal increase on both T1-
and T2-weighted images. Although fat-containing tumors
could have a similar appearance on T1-weighted images, a
chemical-shift technique [16] can be used to distinguish the
two conditions. Disk-space-centered infection (Fig. 5) was
characterized by low signal from the disk space and adjacent
vertebral bodies on T1-weighted images, an appearance pre­
viously described [18]. In the case of the presumed thoracic
disk herniation (Fig. 3), MR differentiated cord, vertebral body,
and disk. Because of the lack of difference in density between
the cord and disk and the lack of contrast material anteriorly
and posteriorly at the level of the lesion, CT myelography did
not identify clearly the cord-disk interface. The diagnosis of
disk herniation was therefore not made before MR was per­
formed. MR also detected the solid component of a cervical
dependymoma by a signal intensity pattern different from pa­
renchyma and CSF, CT myelography could not differentiate
a cystic tumor from a syrinx. In two additional cases of
thoracic meningioma, the relatively low signal of the lesion on
the T2-weighted image suggested the diagnosis, as these
signal characteristics have been noted in intracranial menin­
giomas [17].
Degradation of CT images is common in the lower cervical
region and at the cervical thoracic junction. This is caused by
the sudden increase in X-ray attenuation at the level of the
shoulders. This takes the form of dense, dark streaks across
the images [19]. The degradation often results in total loss of
the diagnostic image at that level. No such degradation is
known in MR, and signal intensity is not attenuated by sur­
rounding tissues. Imaging by MR is far superior than by CT
myelography in this region, as was shown in three cases in
our series.
Another limitation of CT myelography is seen in cases in
which a space-occupying lesion causes block to CSF flow.
The contrast material is stopped by the lesion and outlines
the lower border of the lesion only. To determine the full
extent of the lesion and outline its upper border, contrast
material may be introduced by high cervical puncture. Alter­
natively, the contrast material that has been stopped below
the site of the block may be forced to cross the block using a
"squeeze" technique [20]. Neither of these techniques was
used in our series. High cervical puncture adds to the
invasiveness of the procedure. The squeeze technique is report­
edly without risk; however, its potential added risk cannot be
evaluated until a large series is reported. MR provides com­
plete imaging of the lesion noninvasively.
Although MR was equal or superior to CT myelography in
cord enlargement regardless of the coil used, cases of cord
compression and atrophy demonstrate the need for surface
coils in examining the spine (see Tables 2 and 3). Eight cases
of cord compression and atrophy were examined with surface
coils. MR was superior to CT myelography in four and equi­
valent in two. On the other hand, MR was inferior in five and
equivalent in three of nine cases with the same diagnoses
examined without surface coils.
MR failed in 11 of our cases. However, in eight of these
cases the MR technique was suboptimal. The slice thickness
was 10 mm and the surface coil was not used early in our
experience with the method. There remain three cases in
which the proper technique was used. Analysis of these three
cases attributed the failure of MR to low spatial resolution,
particularly in axial images. For this reason, CT myelography
showed to a better advantage a 2-mm cervical cord cavity
(Fig. 2). The added high-contrast discrimination caused by
entry of contrast material into the cavity enhanced the spatial
resolution. For the same reason, the lateral extent of herniated
cervical disk was not demonstrated by MR (Fig. 6), and small
CSF pockets outlined by arachnoid adhesions were also
missed by MR but well shown by CT myelography. However,
the absence of abnormal findings on MR in cases of arachnoiditis is not without diagnostic value. Indeed, deformity of
the contrast column on myelography and CT myelography
may mimic the presence of intradural or extradural lesions.
The possibility of such lesions can easily be excluded by the
normal appearance on MR images, as shown in one of three
cases of arachnoiditis in our series.
The poor quality of axial images as compared with sagittal
images on MR limits the usefulness of this technique in

<table>
<thead>
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<th>TABLE 5: Value of Surface-Coil Imaging</th>
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<tbody>
<tr>
<td>No. of Cases</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Surface coil</td>
</tr>
<tr>
<td>Nonsurface coil</td>
</tr>
<tr>
<td>Total</td>
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<table>
<thead>
<tr>
<th>TABLE 6: Advantages of MR over CT Myelography in 11 Cases</th>
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</thead>
<tbody>
<tr>
<td>Tissue specificity (n = 6)</td>
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<tr>
<td>Hematotomyxelia</td>
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<td>Cervical ependymoma</td>
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<tr>
<td>Thoracic disk herniation</td>
</tr>
<tr>
<td>Disk-space-centered infection</td>
</tr>
<tr>
<td>Meningioma (n = 2)</td>
</tr>
<tr>
<td>Lack of shoulder artifact (n = 3)</td>
</tr>
<tr>
<td>Cervical disk herniation</td>
</tr>
<tr>
<td>Thoracic cord cavity</td>
</tr>
<tr>
<td>Presumed extruded disc fragment</td>
</tr>
<tr>
<td>No limitation from CSF block (n = 2)</td>
</tr>
<tr>
<td>Meningioma</td>
</tr>
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hand, in the 19 cases in which a surface coil was not used,
MR was superior in only two cases, equivalent in 10, and
inferior in seven.

Discussion

MR compares favorably with CT myelography in cases of
cord swelling and those of cord atrophy and compression if
a surface coil and thin sections are used. Advantages of MR
include tissue characterization, lack of shoulder artifact, and
complete delineation of the lesion in spite of CSF block (Table
6). The contribution of tissue characterization was significant
in six of our 33 abnormal diagnoses. Cord hemorrhage (Fig.
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and T2-weighted images. Although fat-containing tumors
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dependymoma by a signal intensity pattern different from pa­
renchyma and CSF, CT myelography could not differentiate
a cystic tumor from a syrinx. In two additional cases of
thoracic meningioma, the relatively low signal of the lesion on
the T2-weighted image suggested the diagnosis, as these
evaluating lateral lesions. Furthermore, sagittal images are difficult to interpret in cases of scoliosis.

Our results suggest that MR can serve as the primary imaging tool in evaluation of the cervical and thoracic spine. If a surface coil is used, MR is equivalent or superior to CT myelography in cases of cord swelling, cord atrophy, and cord compression. CT myelography, however, appears equal or superior to MR in cases of spondylosis and arachnoiditis. It will likely remain so until improved axial images can be generated with MR. Although not addressed in this study, plain CT of the cervical and thoracic spine could perhaps adequately complement MR in showing bony detail and intervertebral foramina, thus significantly decreasing the need for myelography.

Conclusions

MR was equal or superior to CT myelography in our study in categories of cord swelling, cord atrophy, and cord compression. It provided additional information in six of 33 cases because of improved tissue characterization, in three cases because of lack of shoulder artifact, and in two cases with CSF block. CT myelography offers superior resolution, which was important in four cases. CT was equivalent or superior to MR in cases of spondylosis and arachnoiditis. Surface-coil imaging and thin sections are essential if MR is to be used to evaluate the cervical and thoracic spine.

REFERENCES